

REMARKS

I. Introduction

By the present Amendment, claims 1 and 21 have been amended. No claims have been added or cancelled. Accordingly, claims 1 and 3-21 remain pending in the application. Claims 1 and 21 are independent.

II. Office Action Summary

In the Office Action of January 21, 2011, claims 1 and 9-21 were provisionally rejected on the ground of non-statutory obviousness double patenting as being unpatentable over claims 1-8, 10-13, 15, and 16 of co-pending application 11/577,334; claims 1 and 8 of co-pending application No. 11/913,959; and claims 1-10, 12-15, and 17-19 of co-pending application No. 11/571,782. Claims 1 and 3-21 were rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 6,381,197 issued to Savord et al. ("Savord") in view of U.S. Patent No. 6,183,419 issued to Wildes. These rejections are respectfully traversed.

III. Double Patenting Rejections

Claims 1 and 9-21 were provisionally rejected on the ground of non-statutory obviousness type double patenting as being unpatentable over each of: claims 1-8, 10-13, 15 and 16 of co-pending application No. 11/577,33; claims 1 and 8 of co-pending application No. 11/913,959; and 1-10, 12-15, and 17-19 of co-pending application No. 11/571,782.

Regarding these rejections, the Office Action indicates that although the pending claims are not identical to those of the cited applications, they are not patentably distinct from each other.

As these rejections are only provisional, Applicants elect to wait until the claims of either the instant application or the cited applications have been allowed, or indicated as allowable, in order to take steps most appropriate to address this rejection.

IV. Rejections under 35 USC §103

Claims 1 and 3-21 were rejected under 35 USC §103(a) as being unpatentable over Savord in view of Wildes. Regarding this rejection, the Office Action indicates that Savord discloses a plurality of transducers for transmission and reception of ultrasonic waves for interrogation of objects such as solids which includes a plurality of oscillation elements of equal number being divided into a plurality of groups with equal intervals in a minor and major axis direction that are commonly connected. The Office Action further indicates that the distance between each MUT can be varied for purposes such as aperture control, in addition to production of a different bias for each group for the purpose of apodization and elevation/image depth control. Savord is further indicated as disclosing a terminal with a distribution means that is connected to system electronics for control and bias purposes. The Office Action also indicates that Savord discloses biasing a plurality of oscillation elements to transmit and receive ultrasonic waves which would inherently include a correction control means to dynamically vary the apodization and aperture control such that the bias change would incorporate a correction of the electromechanical coupling coefficient. Savord is additionally relied upon for disclosing application of a bias having weight for groups of MUT elements either symmetrically or asymmetrically in order to control the lateral aperture by selectively controlling the activation of the MUT elements. The Office Action goes on to indicate

that Savord discloses varying the number of energize equipments directly impacts the focal depth, and reduces the number of switches necessary to activate the elements.

The Office Action admits that Savord fails to specifically disclose adjusting the depth based on energizing different numbers of sections of oscillating elements in different groups. Wildes is relied upon for teaching that varying the number of elements can directly impact the quality and focal depth of imaging, and that varying groups of sections and elements can be arranged to optimize the clarity and focal depth of imaging. Wildes is further indicated as disclosing that varying configurations of sections and groups can lead to better sharpness, focus, and resolution at varying depths. The Office Action concludes that it would have been obvious to combine the teachings of Savord with the variable groupings of Wildes in order to arrive at the claimed invention. Applicants respectfully disagree.

By the present Amendment, Applicants have amended the claims to better clarify the features of the invention that do not appear to be disclosed or suggested by the art of record. As amended, independent claim 1 defines an ultrasonic probe that includes a plurality of transducers in an array for converting drive signals into ultrasonic waves to transmit the waves to an object to be inspected and converting the waves into electrical signals to receive ultrasonic waves generated from the object. According to independent claim 1:

each of the transducers comprises a plurality of oscillation elements, each of the oscillation elements has a characteristic of changing an electromechanical coupling coefficient in accordance with strength of a direct-current bias applied by being superposed on the drive signal, and an electrode of each of the transducers is connected to a terminal provided with the drive signal,

the plurality of oscillation elements are divided into a plurality of groups including sections of the oscillation elements, and

a number of the oscillation elements pertaining to each of the sections increases section-by-section as the position gets closer to the center of the ultrasonic aperture along a minor axis direction.

The ultrasonic probe of independent claim 1 includes a plurality of transducers that each comprises a plurality of oscillation elements. Each of the oscillation elements has a characteristic of changing an electromechanical coupling coefficient in accordance with the strength of a direct-current bias applied by being superposed on the drive signal. Each transducer has an electrode that is connected to a terminal provided with the drive signal. The plurality of oscillation elements are divided into a plurality of groups including sections of the oscillation elements. According to independent claim 1, the number of oscillation elements pertaining to each of the sections increases section by section as the position approaches the center of the ultrasonic aperture along a minor axis direction. See paragraphs [0043] and [0061].

The Office Action alleges that the combination of Savord and Wildes discloses all of the features recited in independent claim 1. This does not appear to be the case. Savord discloses a micro-machined ultrasonic transducer which has aperture, elevation, and apodization controlled by an apparatus located on the same substrate as the transducer. Alternatively, a bias voltage control can be applied to the transducer elements. The control apparatus can take the form of field effect transistors, micro-machined relays, or doped regions on the substrate. Savord also discloses a plurality of oscillation elements that are divided into a plurality of groups having an equal number of oscillation elements. However, there appears to be no disclosure or suggestion for increasing the oscillation elements pertaining to each of the sections along the center in a minor axis direction.

Wildes discloses a multiplexer for connecting a beamformer to a multi-row transducer array, wherein the number of electrically independent elements in the transducer is greater than the number of channels in the beamformer, thereby enabling dynamic selection and beamforming control of multi-row apertures. The active aperture can be scanned along at least one axis of the array while its shape is varied electronically. Each beamformer channel can also be connected to a single transducer element for near-field imaging and to a pair of adjacent transducer elements for far-field imaging.

Wildes further indicates that the number of elements decreases toward the center of the aperture. Therefore, the total number of dark gray (or inner aperture) is smaller than medium gray and light gray (surrounding aperture). See column 8, lines 8 and 9, Table 1-2, and Figs. 7 and 8. This disclosure would appear to be somewhat different from the newly added limitation of independent claim 1. Thus, the combination of cited references fails to provide any disclosure or suggestion for features now recited in independent claim 1, such as:

a number of the oscillation elements pertaining to each of the sections increases section-by-section as the position gets closer to the center of the ultrasonic aperture along a minor axis direction.

It is therefore respectfully submitted that independent claim 1 is allowable over the art of record.

Claims 3-20 depend from independent claim 1, and are therefore believed allowable for at least the reasons set forth above with respect to independent claim 1. In addition, these claims each introduce novel elements that independently render them patentable over the art of record.

As amended, independent claim 21 defines a method for ultrasonic imaging that comprises:

applying a direct-current bias to a plurality of oscillation elements possessed by each transducer arrayed in an ultrasonic probe and changing an electromechanical coupling coefficient of each of the oscillation elements to a setting value;

supplying a drive signal to each of the oscillation elements by superposing the drive signal on the direct-current bias, transmitting an ultrasonic wave to an object to be inspected from each of the oscillation elements; and

receiving an ultrasonic wave generated by the object by each of the oscillation elements to convert the wave into an electrical signal and reconstructing an ultrasound image based on the converted electrical signal,

wherein the plurality of oscillation elements are divided into a plurality of groups including sections of the oscillation elements, and

wherein a number of the oscillation elements pertaining to each of the sections increases section-by-section as the position gets closer to the center of the ultrasonic aperture along a minor axis direction.

According to some of the features of independent claim 21, the plurality of oscillation elements are divided into a plurality of groups including sections of the oscillation elements. Furthermore, the number of the oscillation elements pertaining to each of the sections increases section-by-section as the position gets closer to the center of the ultrasonic aperture along a minor axis direction. As previously discussed with respect to independent claim 1, the cited references fail to provide any disclosure or suggestion for such features.

It is therefore respectfully submitted that independent claim 21 is allowable over the art of record.

V. Conclusion

For the reasons stated above, it is respectfully submitted that all of the pending claims are now in condition for allowance. Therefore, the issuance of a Notice of Allowance is believed in order, and courteously solicited.

If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

AUTHORIZATION

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 389.46065X00).

Respectfully submitted,
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Dated: April 12, 2011